NASA Glenn Research Center Broadband Aeronautical Satellite Communications Demonstrations

2nd Integrated CNS Technologies Conference
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The NASA Glenn Ku-Band Aero-Mobile Satellite Communications Terminal

Goal:

Enable demonstration and evaluation of aeronautical satellite communications technologies and key applications for air traffic management and weather data dissemination, in support of NASA's Aviation System Capacity and Safety Goals.

Approach:

Develop a mobile broadband satellite communications terminal for ground mobile and flight demonstration use. Infuse key technologies and develop key demonstration applications.

Demonstration (?):

We originally planned an satcom terminal demonstration, using the ground mobile testbed or NASA's B-757, to coincide with the 2nd Integrated CNS Conference, but many flight schedule changes and technical problems have made it impossible.

The NASA Glenn Ku-Band Aero-Mobile Satellite Communications Terminal

Today's Presentation:

Review the Aero-mobile Satellite Communications Testbed

Describe the Ground Mobile Testbed System

Review the First Flight Demonstrations on NASA's DC-8, December, 2000

Describe the current B-757 Flight Test Configuration

At the Registration Table:

A slide show describing the broadband satellite communications mobile testbeds will be running.

The Ku Band Aero-Mobile Satellite Communications Testbed

Objective: A testbed that can demonstrate and evaluate advanced aeronautical satellite communications technologies, and can also realistically demonstrate and evaluate aeronautical communications applications to advance aviation system capacity and safety.

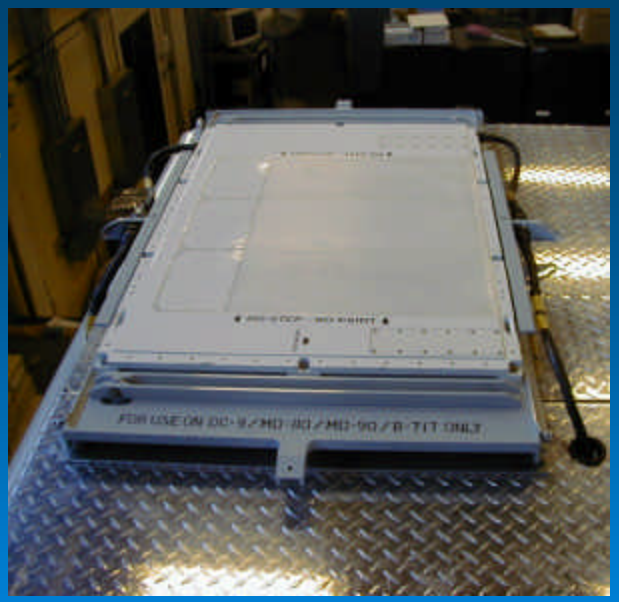
Why Ku Band?

- An opportunity to develop broadband phased array antennas existed at Ku Band. The antennas are the key technology needed to enable broadband satellite communications to aircraft.
- Ku Band satellite links have adequate bandwidth available.
- There are many commercial Ku Band satellites available for use in demonstrations.
- Other satellite communications bands (either lower or higher in frequency) may prove very useful for aeronautical services in the future, but the Ku Band terminal can demonstrate and evaluate many technologies and applications common to all potentially useful bands.
- Note that commercial aeronautical satellite services are now being offered at Ku Band.

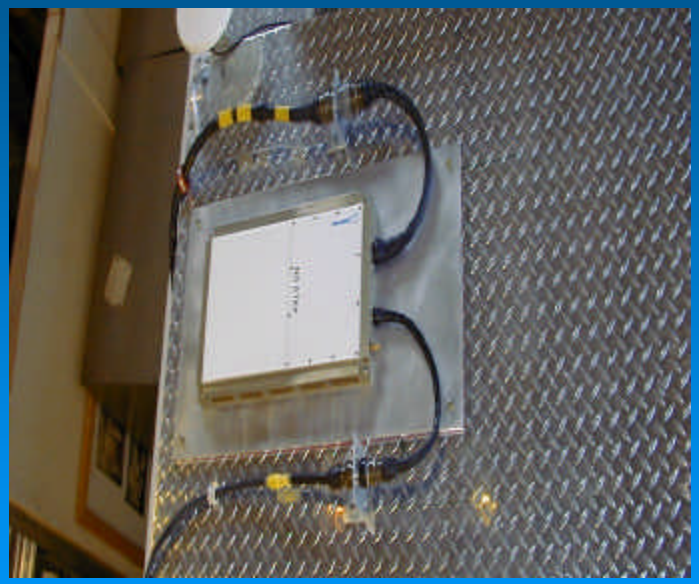
Enabling Antenna Technology

Ku-Band Transmit Array Development

- Boeing developed antenna via GRC cost-share.
- Broadband (active antenna); >256 kbps transmit.
- Low profile; low drag, fuel savings, lower cost.



Ku-Band Receive Phased Array Antenna



Ku-Band Transmit Phased Array Antenna

- Electronic steering; no moving mechanical parts, higher reliability, lower MRO costs.
- Multiple, independent-beam capability; one antenna, multiple satellites.

The Ku Band Aero-Mobile Satellite Communications Ground-Mobile Terminal

The terminal is based on the Boeing transmit and receive antennas.

A ground-mobile test vehicle has been developed to enable day-to-day mobile communications test capability.

Ground mobile experiments will test antenna performance and pointing/tracking algorithms, communications equipment performance, and performance of aeronautical communications networks and applications.

The mobile terminal is also designed for occasional flight experiments to test these parameters under real flight conditions.

The Ku Band Aero-Mobile Satellite Communications Ground-Mobile Terminal

ACCOMPLISHMENTS:

The mobile terminal development and integration is complete; occasional equipment upgrades.

Antenna pointing accomplished with gyro-based INS; GPS-based INS system was tested but not accurate enough.

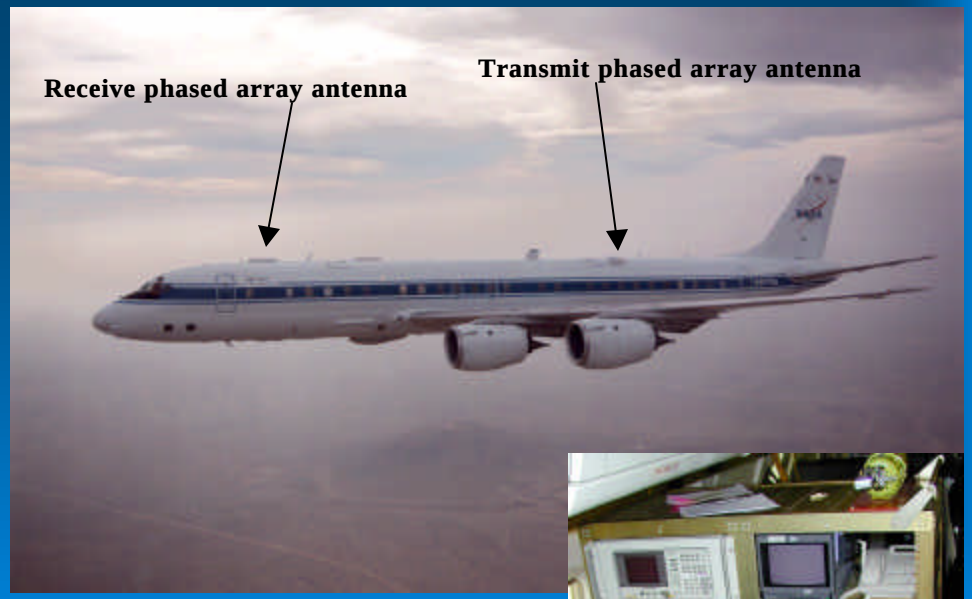
Many trial runs have been completed. Internet connectivity, video transmission, random data for BER measurements have been accomplished.

Overall excellent system performance: 256 kbps uplink from vehicle, 2.4 Mbps downlink to vehicle; sufficient link margin for doubling these rates.

Addition of VDL capability in the future will enable hybrid network testing capabilities.

The Ku Band Aero-Mobile Satellite Communications Flight Test Terminal

First Flight Tests of the Ku-Band Mobile Aero-Satcom Terminal on the NAS DC-8 – Dec, 2000



Demonstrated first ever in-flight network and communications technologies.

Achieved 256 kbps transmit, 2.180 Mbps receive between NASA DC-8 and NASA GRC, DFRC, and ARC.

Sustained connectivity except under extreme bank/roll/heading profiles (e.g., greater than 35 degrees roll).

Conducted simultaneous applications:

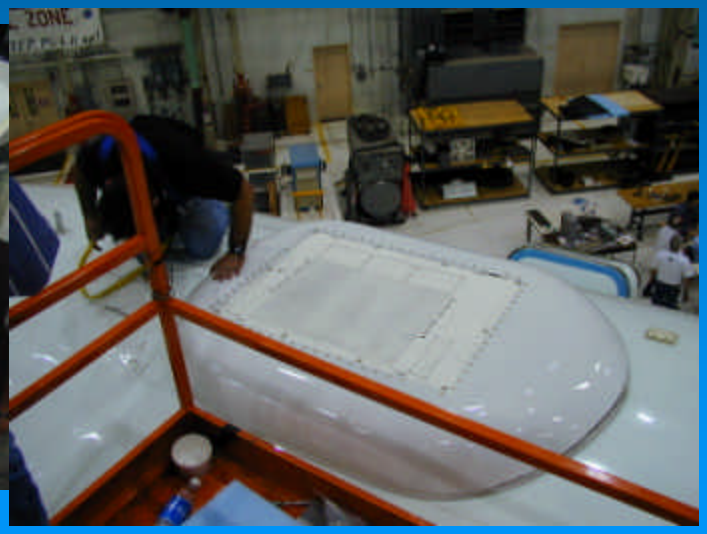
IP (web browsing/serving, email, telnet, FTP, Voice-over-IP)

ATN (Controller Pilot Data Link Communications - CPDLC)

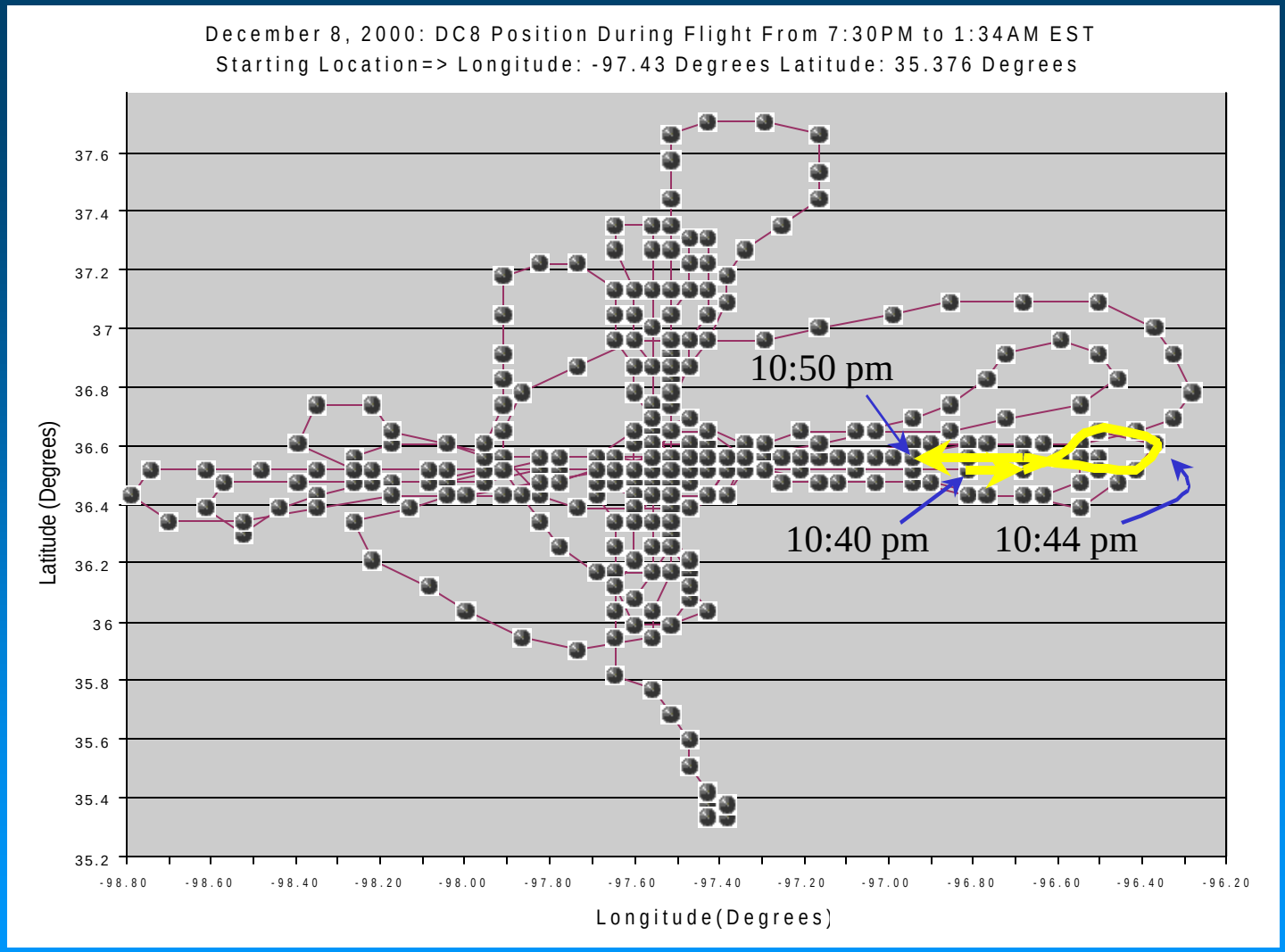
Remote Buffered Network Bus (prioritization and security features)

Live video and DC-8 Digital Air Data System transmission

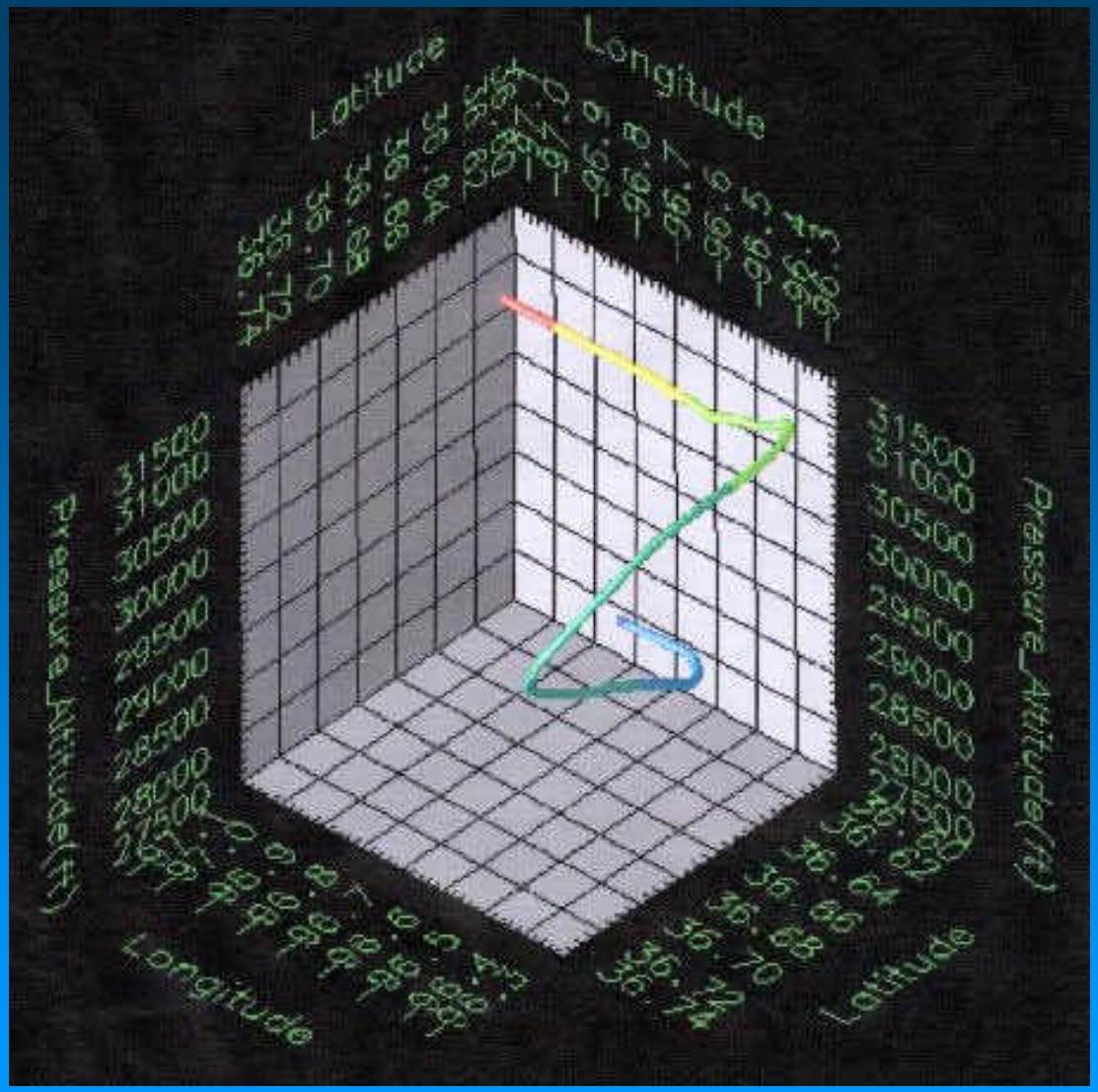
Integrating the Ku Band Terminal with the DC-8



Typical Test Flight Profile



Severe Flight Profile

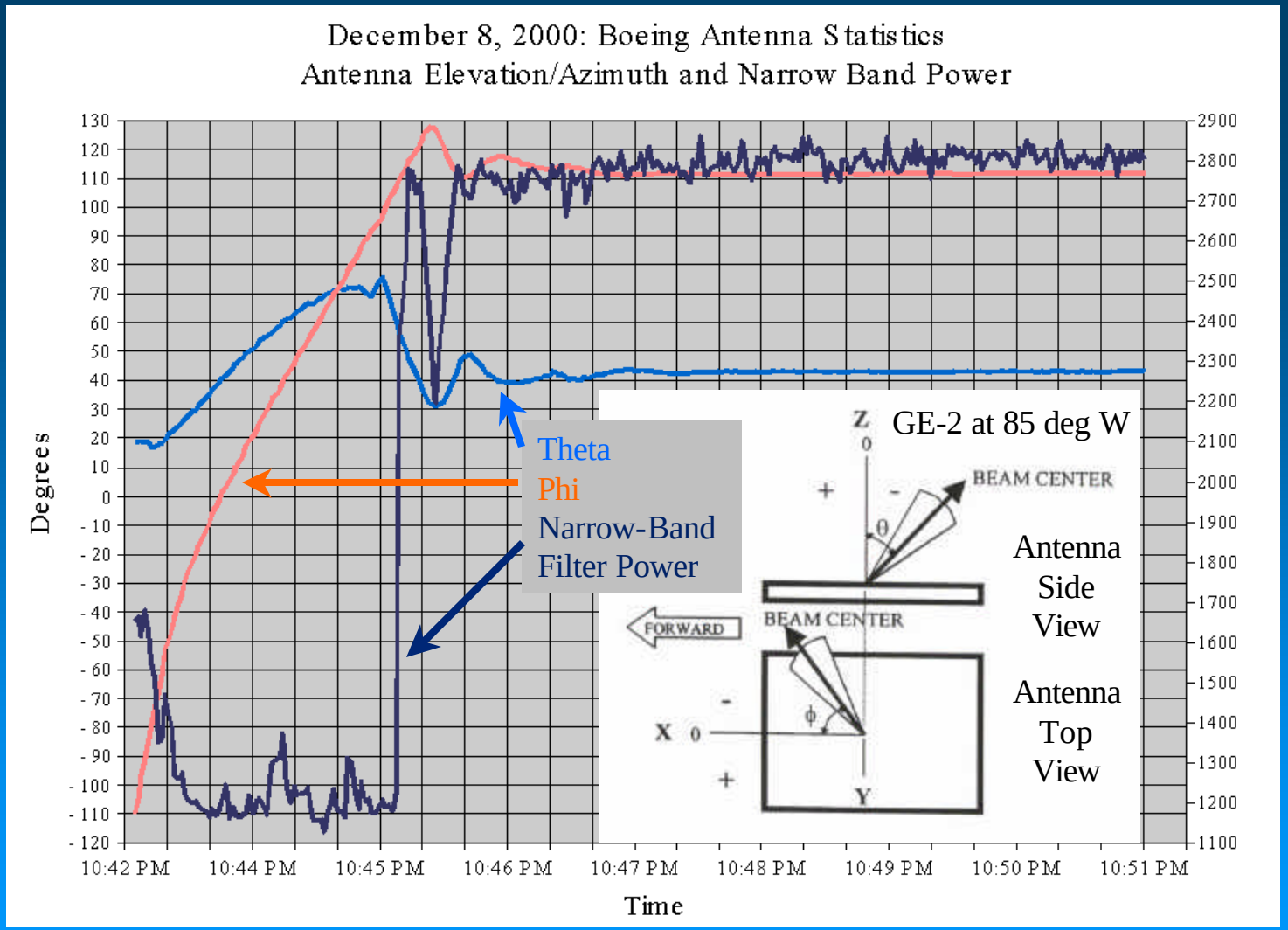


Dec 8, 2000

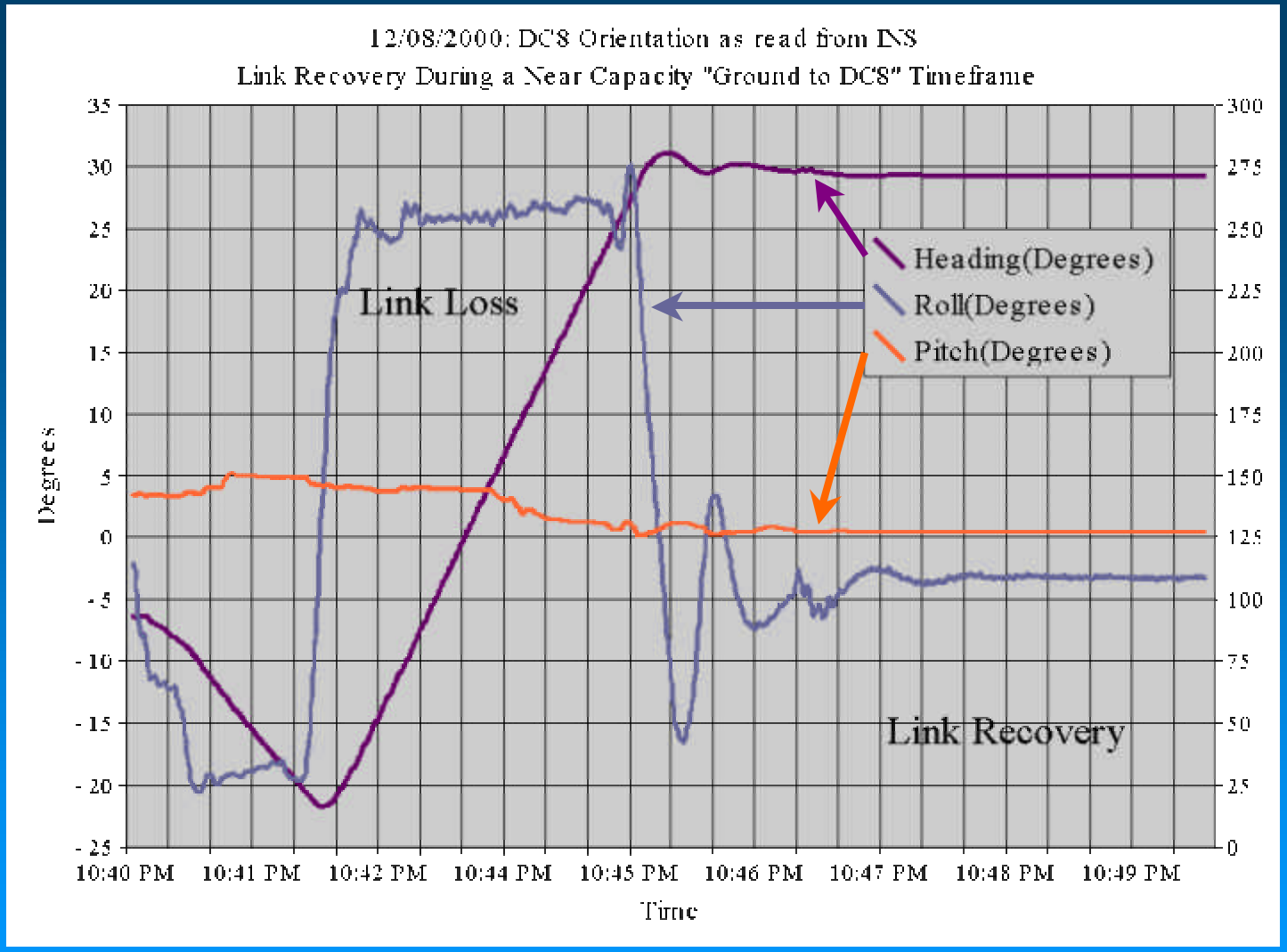
Red = 10:50pm

Blue = 10:40pm

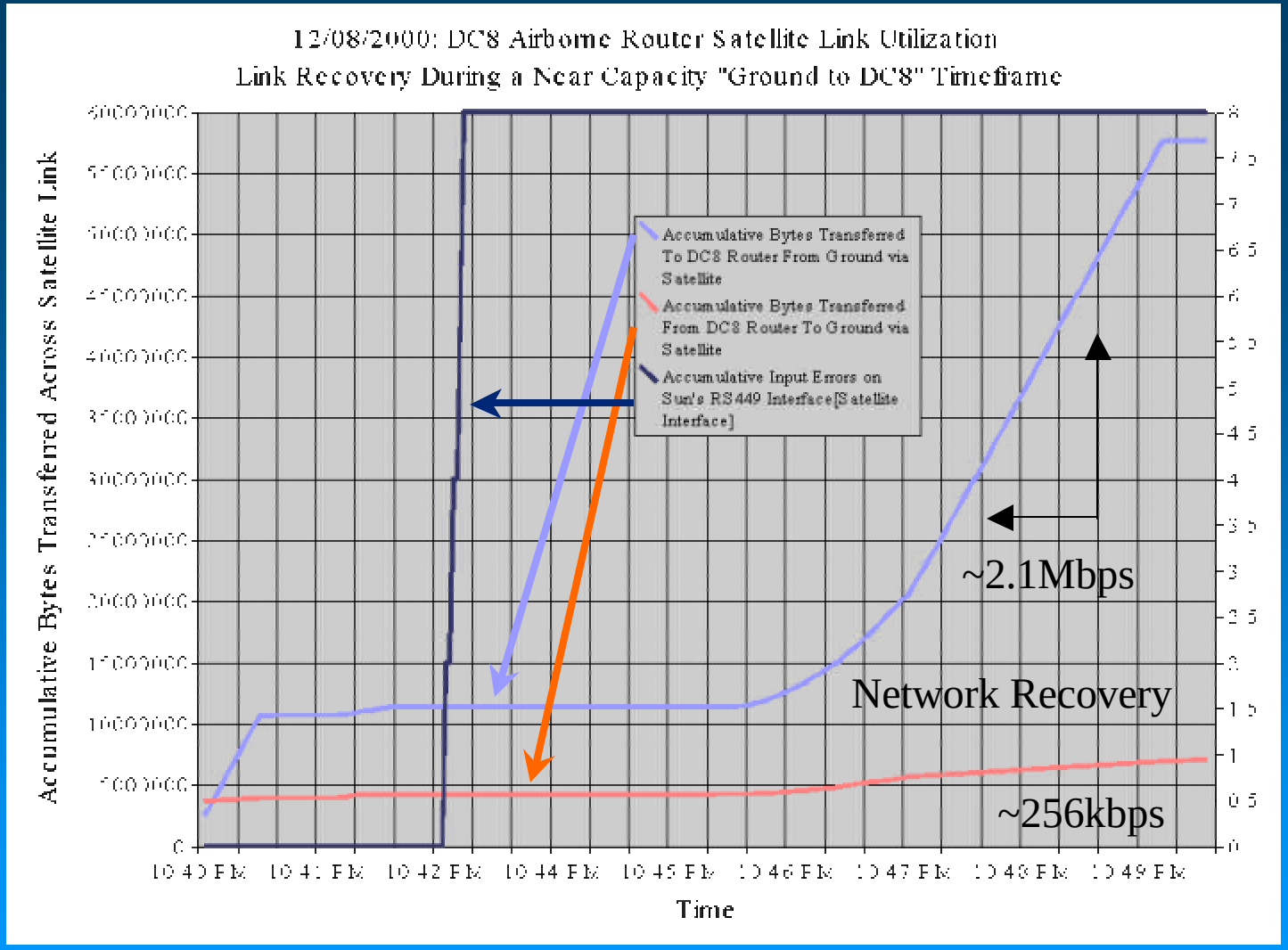
Antenna Performance



Link Recovery



Network Recovery



The DC-8 Experiments

Accomplishments:

- ***First flight tests of the Ku-Band Aero-Mobile SatCom Terminal proved the successful operation of the system.***
- ***Broadband data to and from the aircraft works very well.***
- ***Antenna system will work continuously for most normal civil aircraft operations.***
- ***System recovers reasonably well after signal loss caused by aircraft maneuvers (however we are researching ways of improving this performance).***
- ***Network performance for 3 different network protocols was verified.***
- ***Experience in terminal/aircraft integration has proved valuable for future flight tests with the NASA Langley Boeing 757.***

The Ku Band Aero-Mobile Satellite Communications Flight Test Terminal

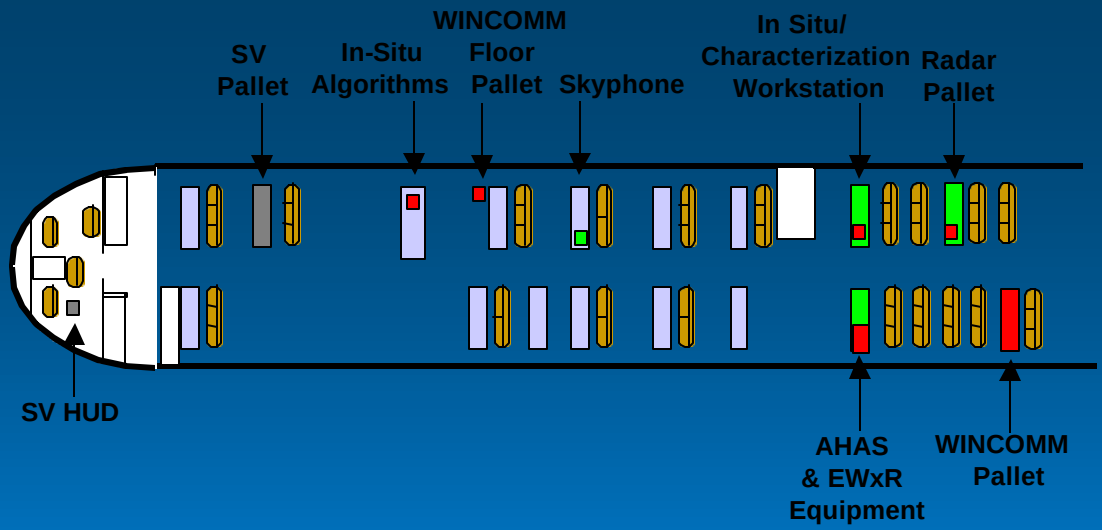
Second Flight Tests of the Ku-Band Mobile Aero-Satcom Terminal on the NASA B-757 – April – May, 2002
(…or, what we wish we were demonstrating during this Conference.)

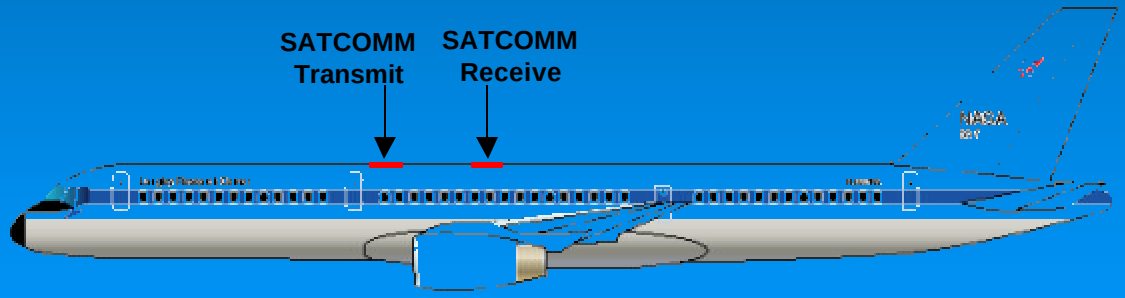
A joint AATT and AvSP flight campaign.

OBJECTIVES:

- Demonstrate delivery of graphical weather data: "*Provide flight deck with higher fidelity, more timely, and intuitive graphical information*"
- Continue testing data transmission and network performance as well as terminal performance.
- Gain experience on the B-757 for future flights.

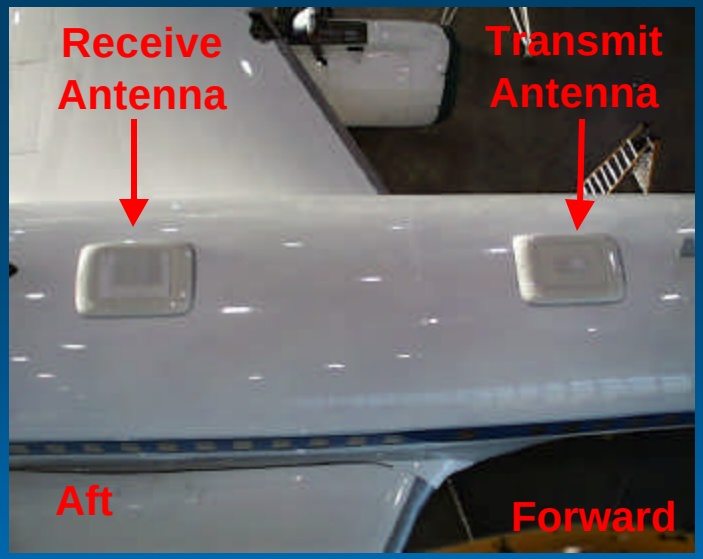
757 Experiment Equipment Layout



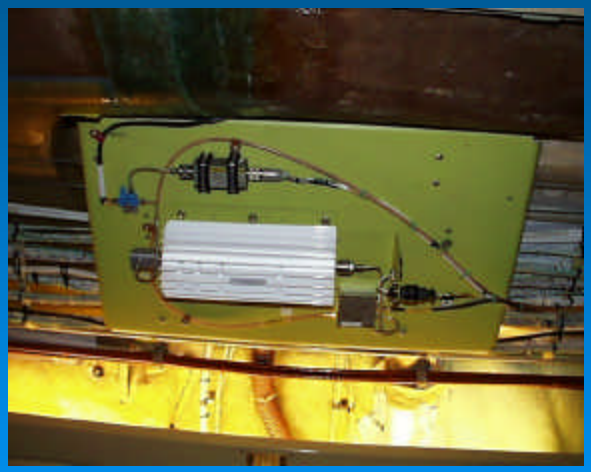


The Ku Band Aero-Mobile Satellite Equipment Installation on the 757

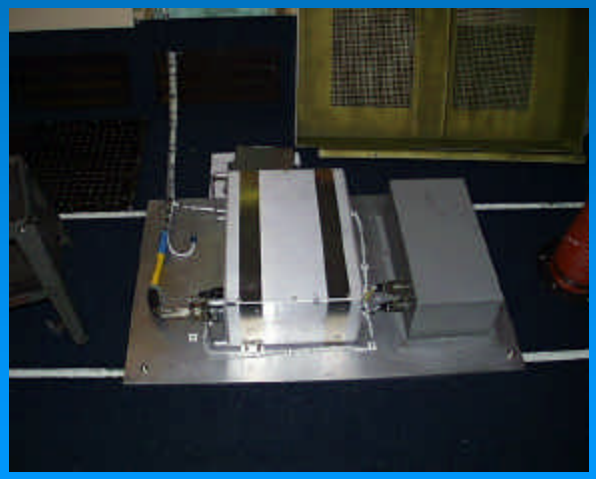
Note that now we use the *Connexion by Boeing* type antenna mounting equipment on the B-757.



Transmit equipment shelf in overhead



Floor pallet in B-757 cabin

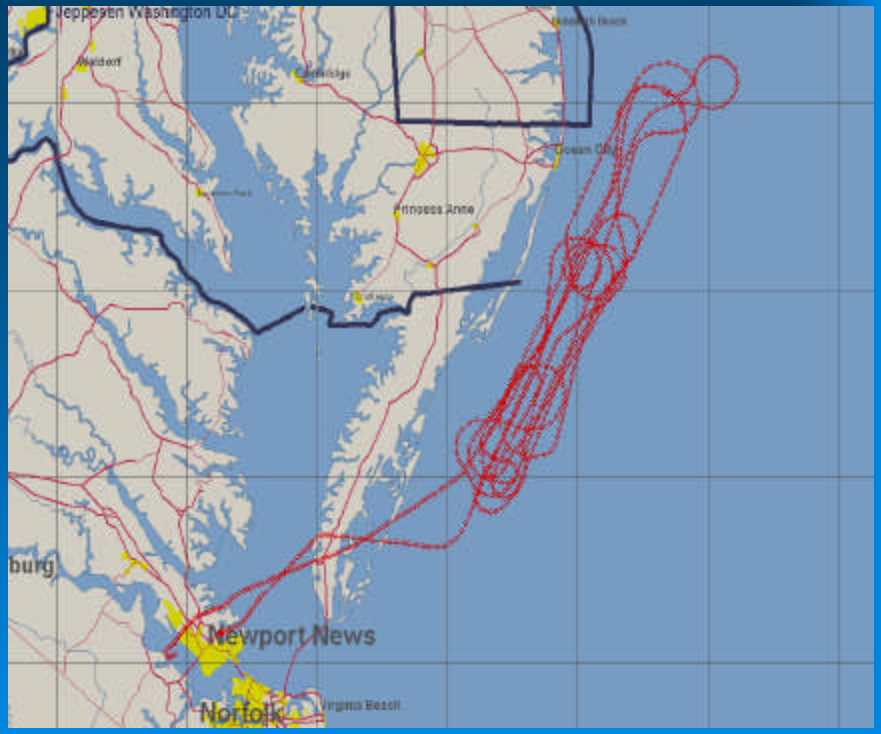


Terminal equipment racks

The Ku Band Aero-Mobile Satellite Communications Flight Test Terminal

Accomplishments to Date:

- ***Completed installation of the Ku Band Terminal on the.***
- ***Equipment checkout completed, performance verified on the ground.***
- ***Initial checkout flight tests completed. Good performance of the Ku Band terminal, except east over the Atlantic Ocean, where the satellite beam power falls off.***
- ***Flight tests continuing during May 2002.***

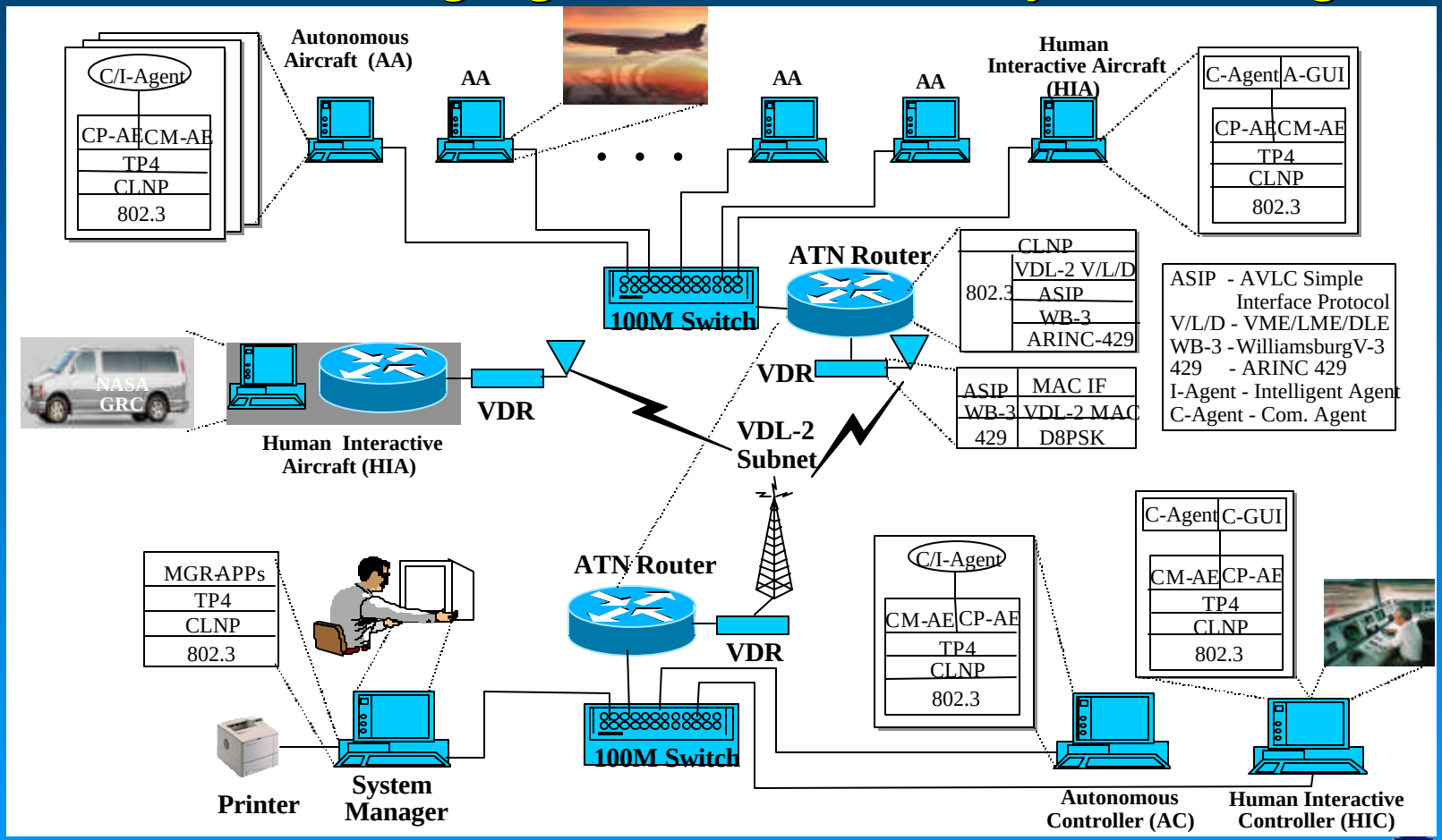


Future Flight Flight Test Plans

- ***Flight tests on the 757 being planned for 2003 and 2004.***
- ***We will be developing ATM-related applications for these flight demonstrations (such as TIS, FIS, CPDLC, ADS, etc.), and network protocols (such as ATN, IPv6, and UMTS).***

The Ku Band Aero-Mobile Satellite Communications Flight Test Terminal

A laboratory testbed will enable emulation of aircraft communications traffic during flight tests…will be ready for 2003 flights.



Summary

- *The Ku Band Aero-mobile Satellite Communications Terminal Testbed has been designed built, tested and verified.*
- *Based on the Boeing Ku Band transmit and receive phased array antennas ("Connexion version 0")*
- *The terminal can be configured in either a ground mobile or air-mobile configuration.*
- *Ground and air mobile testing and experimentation have met with good success – good equipment performance, error-free links, simultaneously applications demonstrated.*
- *We can transmit error-free data at 256 kbps, receive at 2.2 Mbps, and there's enough link margin to at least double those rates.*
- *Ground mobile experiments will continue when the terminal is not in a flight configuration.*
- *Future flights on the B-757 planned for 2003 and 2004.*
- *A laboratory testbed will enable emulation of a crowded airspace.*
- *Advanced applications are being developed for future flight tests.*